

NEW BRACHIOPODS (BRACHIOPODA: ARTICULATA)
FROM THE LATE OSAGEAN OF THE UPPER
MISSISSIPPI VALLEY

JOHN L. CARTER

Curator, Section of Invertebrate Paleontology

ABSTRACT

Two new productid genera and eleven new species of articulate brachiopods are described from the Keokuk Limestone and lower Warsaw Formation of Illinois and Missouri. The new genera are *Keokukia* (type species *Keokukia sulcata*, n. sp.) and *Ozora* (type species *Ozora genevievensis*, n. sp.). Other new species are *Yagonia collinsoni*, *Tomiproductus kollari*, *Keokukia rotunda*, *Cleiothyridina valmeyerensis*, *Acuminothyris keokuk*, *Anthracospirifer brenecklei*, *Spirifer girtyi*, *Punctospirifer monroensis*, and *Plectospira juvenis*.

INTRODUCTION

Recognition of the biostratigraphic position of the Keokuk-Warsaw boundary, or for some workers the Osagean-Meramecian boundary, outside the type region of these formations is not possible with most fossil groups. In particular, microfossils do not at present provide precise means of marking this boundary. In the following discussion the terms lower and upper Warsaw are used in the sense of Van Tuyl (1925).

Over a period of several years I have been collecting brachiopods from the Keokuk and Warsaw with this problem in mind, both in the type region of these formations and elsewhere, but especially to the south in southwestern Illinois and east-central Missouri. Although I cannot report definitive success in the recognition of this boundary by means of brachiopods outside the type region, the new species that are the subject of this paper were collected during this long-term investigation and are described herein in order to supplement our knowledge of the megafauna of this stratigraphic interval.

As an aside, one very distinctive brachiopod species occurs very near the Keokuk-Warsaw boundary in southeastern Iowa and west-central Illinois at most localities. This is the readily recognized, fully costate brachythyridid, *Skelidorygma subcardiiformis* (Hall). Unfortunately, the precise first occurrence of this species has not been well-documented in any stratigraphic section to the south, in the St. Louis region. This species does occur rarely within the moderately fossiliferous upper part of the lower Warsaw Formation of the St. Louis region but does not occur in the highly fossiliferous shales just above the Keokuk Limestone. Therefore, it is possible that the horizon of the type Keokuk-Warsaw boundary of the north is to be found well above the base but within the upper two-thirds of the lower Warsaw of the St. Louis region.

Many of the new taxa that are the subject of this paper were collected mainly from three, presumably discrete horizons within the Keokuk-lower Warsaw sequence. The lowest of these is associated with the mid-Keokuk "oolitic" member

west of St. Louis near the village of Peerless Park, St. Louis County, Missouri. This interval was described in some detail by Brenckle and Lane (1981).

The next younger interval is from the upper Keokuk, well above the mid-Keokuk "oolitic" member in Ste. Genevieve County, Missouri. These beds were interpreted to be part of the Warsaw Formation by Thacker and Satterfield (1977) but are lithologically much more similar to the Keokuk and bear a Keokuk fauna, lacking lower Warsaw indicators. The fauna from these beds also bears very strong similarities to the "Middle Boone" fauna from Batesville, Arkansas, described by Girty (1929).

The presumed youngest fauna is from the highly fossiliferous Warsaw Shale beds just above the Keokuk Limestone in St. Louis County, Missouri, and Monroe County, Illinois. The Illinois section at Dennis Hollow, Monroe County, is described by Collinson et al. (1981). The brachiopod fauna from these basal Warsaw shales consists of numerous characteristic Keokuk species and occurs well below the first occurrence of the typical lower Warsaw indicator, *Spirifer washingtonensis* Weller. In the absence of any lower Warsaw indicators, I suggest that these highly fossiliferous basal lower Warsaw shales are probably coeval with the uppermost Keokuk beds of southeastern Iowa and west-central Illinois.

The stratigraphic ranges of these and other common brachiopod species, plus generalized stratigraphic columns of the middle and upper Keokuk and Warsaw formations for the Mississippi Valley region, will be shown diagrammatically in a future paper.

COLLECTIONS AND STRATIGRAPHIC LOCALITIES

The specimens described and illustrated herein were all collected by the author and his associates or colleagues in the field. Fig. 1 shows where these collecting localities are situated. All primary and secondary types are deposited at The Carnegie Museum of Natural History, Section of Invertebrate Paleontology. The following collecting localities also are registered in this section.

SL431—*Gray's Quarry*, Illinois. Keokuk Limestone, 10 m below base of lower Warsaw. Near Hamilton, SW $\frac{1}{4}$, NE $\frac{1}{4}$, Sec. 31, T.5 N., R.8 W., Hancock County, Illinois.

SL436—*Railroad Spur*, Illinois. Keokuk Limestone, approximately 7.7 m below base of lower Warsaw. About 200 m south of SL431, Hancock County, Illinois.

SL441—*Iowa Gateway Terminal*, Iowa. Lower Warsaw Formation, 3 m above top of Keokuk. Hamilton Quad., NW $\frac{1}{4}$, NW $\frac{1}{4}$, Sec. 30, T.66 N., R.4 W., Lee County, Iowa.

SL442—*Iowa Gateway Terminal*, Iowa. Lower Warsaw Formation, 5.2 m above top of Keokuk. Same coordinates as SL441.

SL447—*Potter's Branch*, Iowa. Keokuk Limestone, base of Keokuk exposed in creek bed. Creek exposure in SE $\frac{1}{4}$, SE $\frac{1}{2}$, Sec. 9, Bonaparte Twp., Van Buren County, Iowa.

SL458—*Little Saline Creek South*, Missouri. Lower Keokuk Limestone, 1 m below mid-Keokuk "oolitic" member. East side of I55 roadcut just south of Little Saline Creek, between mileage markers 141 and 142, Ste. Genevieve County, Missouri.

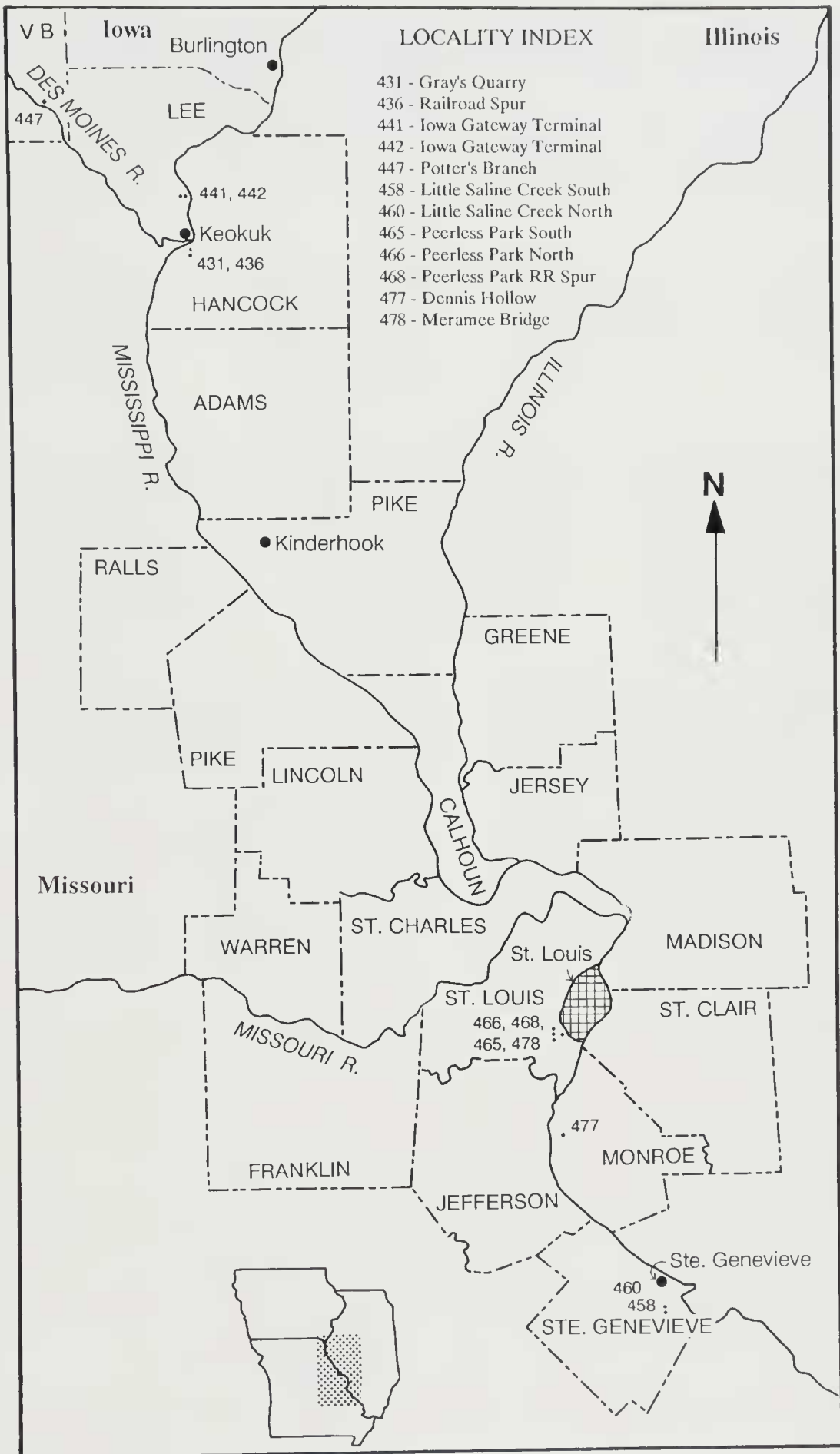
SL460—*Little Saline Creek North*, Missouri. Upper Keokuk Limestone, 7.5 m above top of mid-Keokuk "oolitic" member. East side of I55 roadcut, about 1 km north of Little Saline Creek, between mileage markers 142 and 143, Ste. Genevieve County, Missouri.

SL465—*Peerless Park South*, Missouri. From the mid-Keokuk "oolitic" member. Roadcut on south side of south access road from I44, just east of Peerless Park intersection, Kirkwood Quad., SW $\frac{1}{4}$, NW $\frac{1}{4}$, Sec. 20, T.44 N., R.5 E., St. Louis County, Missouri.

SL466—*Peerless Park North*, Missouri. From the mid-Keokuk "oolitic" member. Roadcut on north side of the north access road from I44, east of Peerless Park intersection, Kirkwood Quad., SE $\frac{1}{4}$, NW $\frac{1}{4}$, Sec. 20, T.44 N., R.5 E., St. Louis County, Missouri.

→

Fig. 1.—Map showing collecting localities in the Keokuk and Warsaw formations. The numbers refer to stratigraphic locality collections in The Carnegie Museum of Natural History.



SL468—*Peerless Park RR Spur*, Missouri. Keokuk Limestone, 0.7 m below the mid-Keokuk “oolitic” member. Roadcut on south side of railroad spur, NW¼, NE¼, Sec. 20, T.44 N., R.5 E., St. Louis County, Missouri.

SL477—*Dennis Hollow*, Illinois. Lower Warsaw Formation, basal 4 m. North side of Illinois 156 roadcut through Dennis Hollow, east of Valmeyer, Valmeyer Quad., NW¼, SE¼, Sec. 2, T.3 S., R.11 W., Monroe County, Illinois.

SL478—*Meramec Bridge*, Missouri. Lower Warsaw Formation, basal 5 m. South side of I44 roadcut just east of bridge over Meramec River, Kirkwood Quad., SW¼, SE¼, Sec. 14, T.44 N., R.5 E., St. Louis County, Missouri.

SYSTEMATIC PALEONTOLOGY

The suprageneric classification used here mainly follows that of the Treatise on Invertebrate Paleontology.

Phylum Brachiopoda Duméril
 Class Articulata Huxley
 Order Strophomenida Öpik
 Suborder Chonetidina Muir-Wood
 Superfamily Chonetacea Bronn
 Family Anopliidae Muir-Wood
 Genus *Yagonia* Roberts, 1976
Yagonia collinsoni, new species
 Fig. 2.1–2.13

Holotype.—Fig. 2.12, a brachial valve interior, CM 34880, collected by the author from locality SL436, upper Keokuk Limestone, Hancock County, Illinois.

Paratypes.—Fig. 2.1–2.11, 2.13, four pedicle valve exteriors, four brachial valve exteriors, three brachial valve interiors, and a small slab with two pedicle valve interiors, CM 34869–34879, 34881, respectively; all from the same collection as the holotype.

Description.—Slightly smaller than type species, moderately concavo-convex, transversely subquadrate to subovate in outline; maximum width attained slightly posterior to mid-length with subangular lateral extremities; ears small, defined by weakly concave flexures on pedicle valve, more weakly defined on opposite valve; ornament of both valves essentially lacking except for strong irregularly-spaced growth varices and much weaker growth lines, weakly capillate in spalled or abraded specimens.

Pedicle valve moderately convex, most convex in or slightly anterior to umbonal region; venter arched, lateral slopes almost flattened in anterior profile, sloping evenly to lateral margins; ears slightly compressed, very weakly reflexed; beak small, broad, slightly overhanging hingeline; at least five pairs of fine spine bases along cardinal margin, up to nine pairs of fine spine tubules within ventral interarea; angle of spines high but not accurately measurable; ventral interarea low, approximately orthocline or slightly apsacline; delthyrium not observed; interior with very long stout median septum, extending three-quarters distance to anterior margin; teeth not observed; muscle scars very large, delimited by low thickened marginal ridge; diductors with several long straight thin radial ribs extending to marginal ridge; adductors small, elongate, poorly differentiated; lateral and anterior margins costellate; few endospines present, mostly confined to aurications.

Brachial valve thin, flattened, weakly and evenly concave except for flatter, poorly delimited aurications; dorsal interarea very low or lacking, not observable; interior with distinct marginal ridge as in opposite valve; cardinal process large, ventrally raised, elongated, bilobed, supported by short thick median ridge that extends forward only to posterior portions of accessory septa; alveolus lacking; sockets large and deep, buttressed by strong high inner socket ridges; anderidea well-developed, extending forward from inner socket ridges; pair of strong diverging accessory septa extend forward to marginal ridge, laterally flanked by numerous weaker ridges or septa that are composed of fused, radially arranged endospines and essentially delimiting area of brachial ridges.

Measurements.—See Table 1.

Distinguishing characters.—This species differs from all other North American

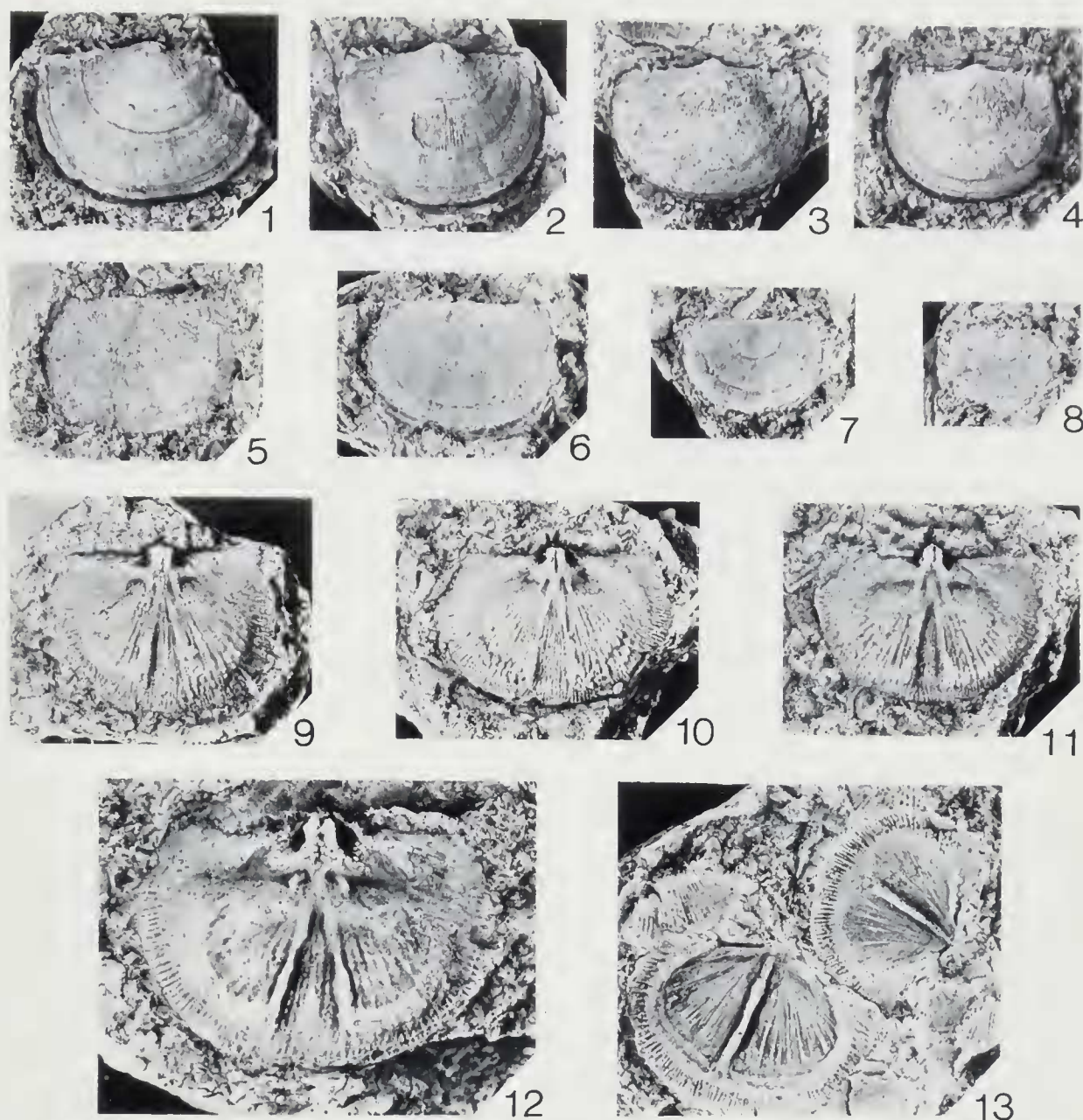


Fig. 2.—*Yagonia collinsoni* n. sp.; 2.1–2.4, four pedicle valve exteriors, CM 34869–34872, respectively; 2.5–2.8, four brachial valve exteriors, CM 34873–34876, respectively; 2.9–2.11, three brachial valve interiors, CM 34877–34879, respectively; 2.12, the holotype, a brachial valve interior, CM 34880; 2.13, small slab with two pedicle valve interiors, CM 34881; all $\times 1.5$ except 2.12, $\times 2$.

Lower Carboniferous chonetids in its combination of unusual cardinalia, marginal rims in both valves, very long ventral septum and smooth exteriors.

Remarks.—*Yagonia collinsoni* n. sp. is very similar to the type species, *Yagonia gibberensis* Roberts, 1976, from the late Visean or early Namurian of New South Wales. The latter differs in having a larger and broader umbonal region and a more strongly arched venter. It is readily differentiated from other North American chonetids of similar age such as *Chonetes planumbonus* Meek and Worthen and *Chonetes shumardanus* DeKoninck. The former species is much smaller, with fewer hinge spines, and has a flattened ventral umbonal region and a strongly concave brachial valve. The latter is capillate, has low angled hinge spines, an hypercline dorsal interarea, and a rugosochonetinid interior.

Table 1.—Measurements (in mm) of the types of *Yagonia collinsoni*, new species.

Specimen no.	Locality	Length	Width
CM 34869	SL436	12.2	±17.8
CM 34870	SL436	12.7	16.2
CM 34871	SL436	10.7	15.7
CM 34872	SL436	10.5	13.8
CM 34873	SL436	10.8	14.7
CM 34874	SL436	10.1	14.7
CM 34875	SL436	7.4	10.8
CM 34876	SL436	5.6	8.2
CM 34877	SL436	10.4	13.0
CM 34878	SL436	9.3	13.7
CM 34879	SL436	9.2	13.3
CM 34880	SL436	9.9	14.2

Distribution.—This species is known only from a single collection of 87 specimens from locality SL436, Hancock County, Illinois.

Suborder Productidina Waagen
 Superfamily Productacea Gray
 Family Buxtoniidae Muir-Wood and Cooper
 Genus *Tomiproductus* Sarycheva, 1963

Tomiproductus kollari, new species

Fig. 3.1–3.14

Holotype.—Fig. 3.1–3.4, a pedicle valve, CM 34882, collected by A. Kollar, April 1989, from locality SL465.

Paratypes.—Fig. 3.5–3.14, two pedicle valves and a natural mold of a brachial valve exterior, CM34883–34885, respectively, all collected by the author, from the same locality as the holotype.

Description.—Medium size for genus, longer than wide, greatest width attained at or near hingeline in holotype but anteriorly on trail in both pedicle valve paratypes; outline in ventral view subovate; outline of visceral disc subquadrate; lateral profile subtrigonal to guttate; ears well-defined, of moderate size, subangular, mucronate, laterally compressed; both valves geniculate; trail long, not spreading, with nearly parallel flanks; body cavity moderately thick.

Pedicle valve strongly inflated, most convex near beak and where geniculation begins at anterior edge of visceral disc; umbonal region broad; beak small, overhanging hingeline; venter flattened but weakly convex, lacking sulcus; flanks parallel to subparallel, nearly vertical, sloping steeply to lateral margins; ears delimited by distinctly concave flexures; ornament consisting of numerous rounded coarse costellae, originating near beak, about 9 per 5 mm on trail venter, becoming weak or obsolete on flanks near ears, with occasional bifurcations or intercalations, especially near anterior edge of visceral disc; rugae on visceral disc moderately strong, especially on sides of umbonal region; small erect spine bases sparsely and irregularly scattered over trail, generally on crests of costellae; irregular row of 6–8 spines, beginning at hingeline on each side of umbo, wrapping around ears to posterolateral flanks; growth lines fine, sinuous, irregularly spaced; interior unknown.

Brachial valve strongly geniculated, visceral disc weakly concave; ears well-delimited by convex flexures dorsally and concave flexures on posterolateral extremities; trail moderately long, moderately concave on dorsum, less concave on flanks; ornament complementary to that of opposite valve, except spine bases lacking; interior with short bilobed sessile cardinal process; supported by stout median septum that extends forward almost to anterior edge of visceral disc; lateral ridges stout; other internal details not observed.

Measurements.—See Table 2.

Distinguishing characters.—This species can be differentiated by its angular



Fig. 3.—*Tomiproductus kollari* n. sp.; 3.1–3.4, ventral, anterior, posterior and lateral views of the holotype, a pedicle valve, CM 34882; 3.5–3.12, ventral, anterior, posterior and lateral views of two pedicle valves, CM 34883 and 34884, respectively; 3.13, 3.14, ventral and lateral views of a natural mold of a brachial valve exterior, CM 34885; all $\times 1$.

mucronate laterally compressed ears, decisively rugose visceral disc, consistently parallel flanks, and, especially, the row of spines that wraps around the ears onto the posterolateral flanks.

Remarks.—The two North American species of this genus are very similar, both internally and externally, and the differences between them, although taxonomically important, are subtle and require good specimens for accurate identification. *Tomiproductus gallatinensis* (Girty) is a fairly common constituent of the brachiopod faunas of the Lodgepole Limestone, Banff Formation, Joana Limestone, and Redwall Limestone of the Cordilleran Region. It ranges in age from very late Kinderhookian to about middle Osagean. It differs from this new Keokuk species in having a weakly rugose visceral disc; it commonly has moderately spreading flanks, less angular non-mucronate ears, and lacks a row of spines that wrap around the ears onto the postero-lateral portions of the flanks.

Two of the three Soviet species described by Sarycheva (1963), *Tomiproductus elegantulus* (Tolmachoff) and *T. dukhovae* Sarycheva, both from the Tournaisian of the Kuznets Basin, are generally similar to *T. kollari* n. sp. but can be distinguished in the following manner. *Tomiproductus elegantulus* is usually slightly smaller, has weaker rugae on the visceral disc, and the spines around the ears are

Table 2.—Measurements (in mm) of the types of *Tomiproductus kollari*, new species.

Specimen no.	Locality	Length	Width	Height	Surface meas.
CM 34882	SL465	22.7	20.4	14.8	43.4
CM 34883	SL465	22.8	21.2	15.2	43.0
CM 34884	SL465	19.6	+18.7	14.6	37.4
CM 34885	SL465	15.7	18.6	8.0	24.0

more numerous and rarely arranged into a single row wrapping around the ears. *Tomiproductus dukhovae* is larger, with coarser ribbing and more numerous spines on the flanks.

With the description of this new species, the range of the genus is now extended from very late Kinderhookian to late Osagean or approximately middle Tournaisian to middle Visean. This midcontinent species records the first occurrence of this genus outside the Kuznets Basin of Siberia or the Cordilleran Region of western North America.

Distribution.—The above description is based on a single collection of eleven specimens, including the four types, from locality SL465, St. Louis County, Missouri. It also occurs in the middle and upper Keokuk Limestone in its type region and in the middle Keokuk of Ste. Genevieve County, Missouri.

Family Dictyoclostidae Stehli
Subfamily Dictyoclostinae Stehli

Genus *Ozora*, new genus

Type species.—*Ozora genevievensis*, n. sp., from the lower Keokuk Limestone of Ste. Genevieve County, Missouri.

Diagnosis.—Large, strongly inflated, geniculate dictyoclostids with transversely subquadrate outline; greatest width at lateral extremities; lateral slopes steep, subparallel, flaring very little; ears large, subangular, vertically compressed; fold and sulcus moderately developed; body cavity moderately thick; pedicle valve strongly convex with greatest convexity in umbonal region and at point of geniculation; brachial valve strongly geniculate, visceral disc weakly to moderately concave; both valves strongly reticulate on visceral disc; in addition, ornament of both valves consists of costae and irregular plications on flanks and trail; pedicle valve with row of spines along hingeline and band of scattered spines across flanks and venter of trail; brachial valve lacking spine bases; cardinal process large, sessile, bilobed or trilobed in dorsal view, with strong median lobe in some specimens; median septum broad and long, stoutly supporting cardinal process, extending forward at least three-quarters length of visceral disc; lateral ridges diverging slightly from hingeline laterally, wrapping around ears and joining with low rim that delimits entire visceral disc; muscle field consisting of larger weakly dendritic posterior adductor scars and smaller, smooth anterior adductors; brachial ridges given off almost horizontally.

Comparisons.—This new genus is most similar to the dictyoclostid genera *Pugilis* Sarycheva, 1949, *Reticulatia* Muir-Wood and Cooper, 1960, *Squamaria* Muir-Wood and Cooper, 1960, and to the alleged linoproductid genus *Marginirugus* Sutton, 1938. It is externally similar to all three dictyoclostid genera in general shape and reticulate ornamentation, and internally is similar in having a marginal rim around the visceral disc. It differs from all three in having both valves geniculated, a well-developed fold and sulcus, no spines on the brachial valve, and in lacking spines on the ears, except for those that form part of a row along the hingeline.

Marginirugus is much larger than *Ozora*, has finer ribbing, weak reticulation, a fold and sulcus is rarely developed, and the pedicle valve is rarely geniculated, although in some specimens it is decidedly so. *Marginirugus* also has rare, scattered, fine spine bases on the pedicle valve, unlike *Ozora*, which has a concentration or band of spines on the trail. The similarities between these two genera

are more telling. Both are large, similarly ribbed, with strongly geniculate brachial valves, have a row of spines along the hingeline, and lack spines on the sides of the ears. The brachial valve exteriors of the two are virtually indistinguishable, except for size, and even then the two overlap. The brachial valve interiors are very similar with a nearly flat visceral disc, strong trilobate cardinal processes, massive long median septa, smooth anterior adductors, horizontal brachial ridges, and most important, a distinct marginal ridge extending around the visceral disc.

Muir-Wood and Cooper (1960) assigned *Marginirugus* to the Family Lino-productidae, a family characterized by concave brachial valves and thin body cavities. In my opinion *Marginirugus* is more likely to be related to the dictyoclostids, especially the genus *Ozora*.

Species assigned.—*Productus crawfordsvillensis* Weller, 1914, can definitely be placed here. Based on exterior shape, ornament, and spine base distribution, *Productus mesialis* Hall, 1858, might belong here, but to my knowledge the dorsal interior of this species never has been described or illustrated. In any case, *Productus mesialis* is probably a dictyoclostid and not a buxtoniid such as *Marginatia* because it has a row of coarse spines just anterior to the ventral hingeline.

Derivation of name.—Named after the village of Ozora, Ste. Genevieve County, Missouri.

Ozora genevievensis, new species

Fig. 4.1–4.13, 5.1–5.4

Holotype.—Fig. 4.1–4.5, a complete shell, CM 34893, collected by the author from locality SL458, Ste. Genevieve County, Missouri.

Paratypes.—Fig. 4.6–4.13, two large pedicle valves, CM 34894, 34895; Fig. 5.1–5.4, four brachial valve interiors, CM 34896–34899, all from the same collection as the holotype.

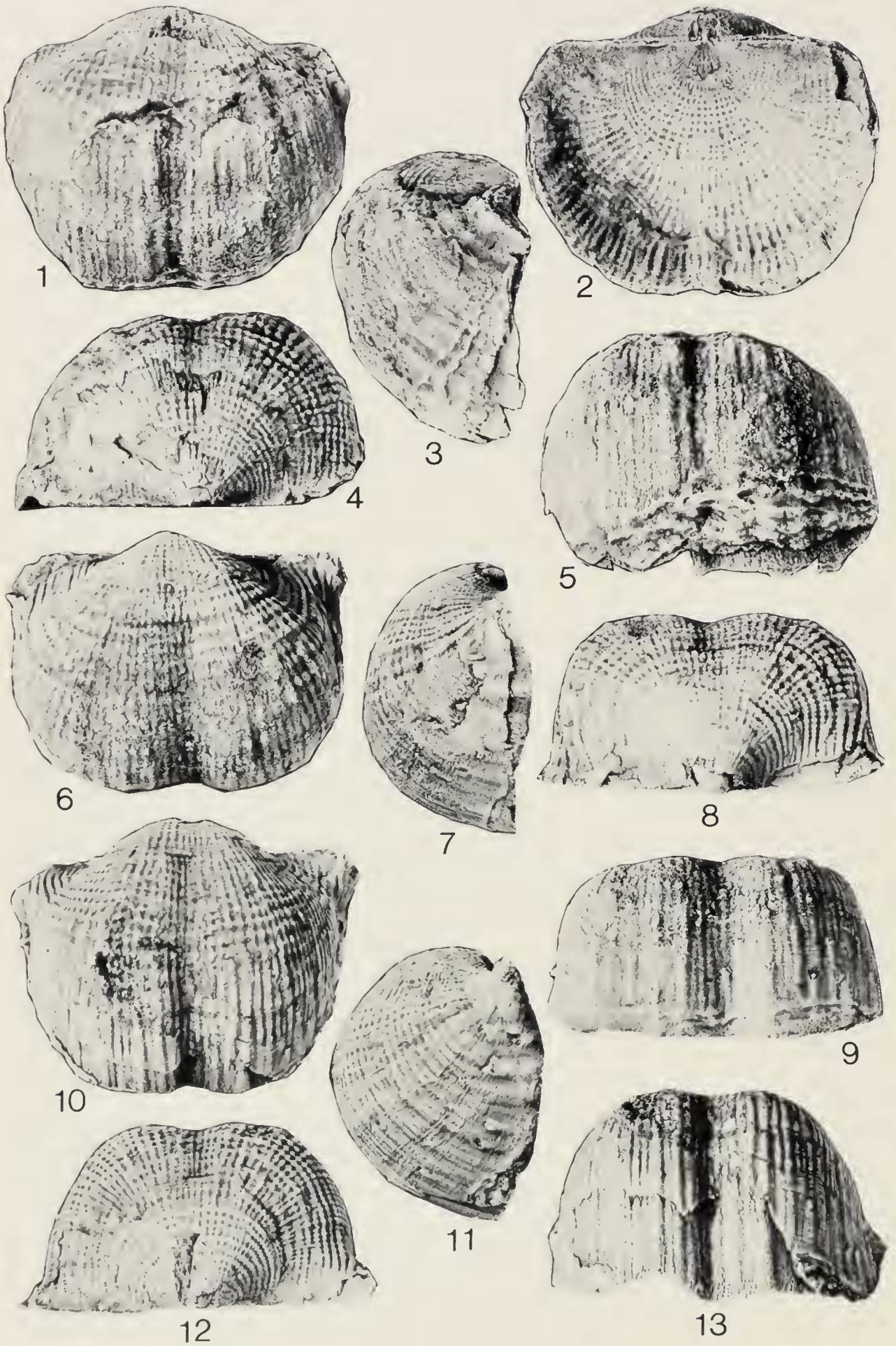
Description.—Medium size for family, pedicle valve strongly convex, geniculate; wider than long, greatest width at hingeline; outline transversely subquadrate; lateral profile subtrigonal; ears large, well-defined; fold and sulcus well-developed, originating in umbonal region; body cavity thick.

Pedicle valve with moderately convex visceral disc, except for concave flexures defining ears, most convex at umbo and at point of geniculation; flanks and trail weakly convex; flanks subparallel, sloping steeply to lateral margins; trail moderately long; beak small, scarcely overhanging hingeline; ornament of visceral disc consisting of numerous fine costae that increase by both intercalation and bifurcation intersecting numerous nearly regular rugae, forming reticulate pattern; spine bases on visceral disc very rare, usually found near point of geniculation, except for single row of five pairs on hingeline; flanks usually with weaker costation plus low irregular plication; trail with stronger costae of variable strength; sulcus increasing in width and depth to anterior edge of visceral disc, becoming uniformly wide and deep on trail; moderately coarse erect spine bases more or less evenly scattered on flanks and trail, usually lacking on sides of ears; growth lines fine, sinuous and regularly spaced; interior with large trigonal incised muscle field, diductors longitudinally ridged, adductors narrow and elongate.

Brachial valve with weakly concave, almost flat, visceral disc with slight flexures delimiting ears; trail and lateral slopes weakly concave; trail short, about normal to visceral disc; fold originating in posterior half of visceral disc, becoming most prominent on trail; ornament complementary to opposite valve; spine bases apparently lacking; interior with stout, sessile internally bilobed or trilobed cardinal process, trilobed in external view, supported by thick tapering long median septum that extends posteriorly three-quarters length of visceral disc; lateral ridges diverging slightly from hingeline, wrapping around cardinal extremities and forming distinct low ridge around entire visceral disc; posterior adductors medium to small in size, weakly dendritic; anterior adductors more deeply incised, smooth or with single longitudinal ridge; brachial ridges given off almost horizontally, extending anteriorly almost to edge of marginal ridge; radially arranged elongated endospines on trail.

Measurements.—See Table 3.

Distinguishing characters.—This species can be differentiated from similar species



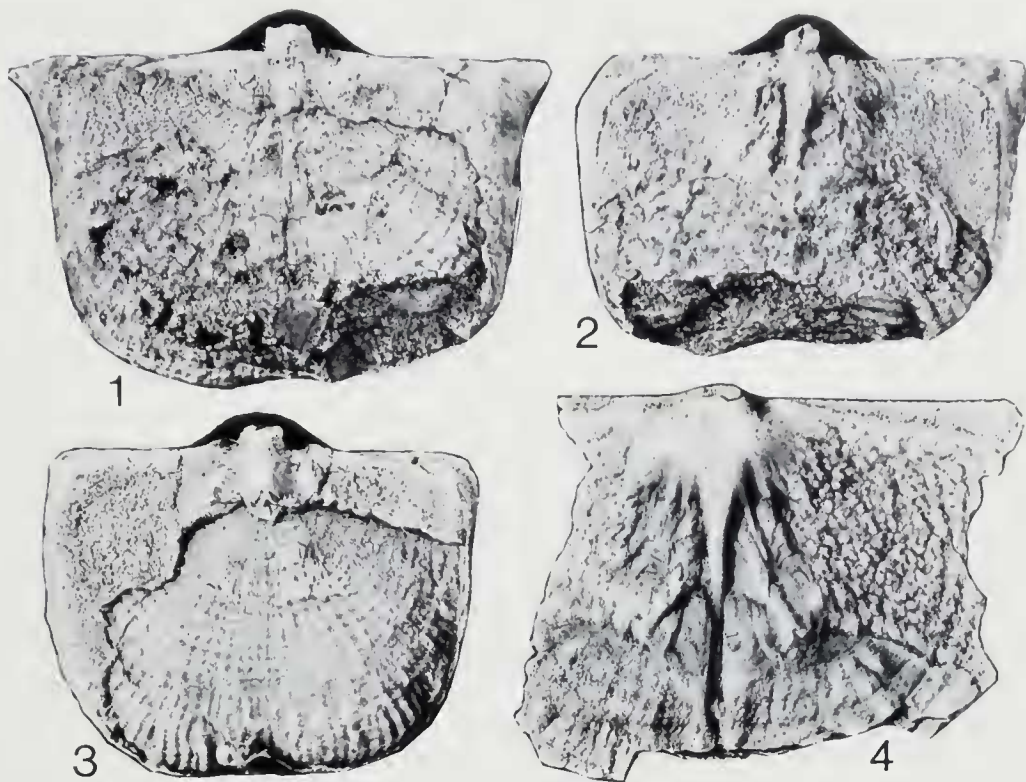


Fig. 5.—*Ozora genevievensis*, n. gen., n. sp.; 5.1–5.3, three brachial valve interiors, CM 34896–34898, respectively, $\times 1$; 5.4, enlarged view of posterior platform of brachial valve interior, CM 34899, $\times 2$.

by its transverse outline, relatively coarse costation, becoming irregular in strength on the trail, its large, laterally compressed ears, and a sulcus that originates in the umbonal region.

Remarks.—Only one other previously described species, *Productus crawfordsvillensis* Weller, is closely similar to this new species. *Productus crawfordsvillensis* differs in having finer costation, smaller ears, a weaker fold-sulcus that originates more anteriorly, and a less transverse outline. No specimen of *Ozora genevievensis* has been found with more than five pairs of spines along the hingeline, whereas Weller (1914) described *P. crawfordsvillensis* as having as many as eight pairs.

Distribution.—This description is based on collections totaling 64 specimens from the lower Keokuk Limestone at locality SL458, Ste. Genevieve County, Missouri.

Genus *Keokukia*, new genus

Type species.—*Keokukia sulcata* n. sp. from the basal Warsaw shales of St. Louis County, Missouri, and Monroe County, Illinois. These beds are judged to be an age equivalent of the uppermost type Keokuk Limestone.

Diagnosis.—Medium sized, strongly inflated productaceans with transversely to longitudinally subovate outline; pedicle valve strongly convex, not geniculate, most convex in umbonal region; brachial valve with moderately concave visceral

←

Fig. 4.—*Ozora genevievensis*, n. gen., n. sp.; 4.1–4.5, ventral, dorsal, lateral, posterior and anterior views of the holotype, CM 34893; 4.6–4.13, ventral, lateral, posterior and anterior views of two pedicle valves, CM 34894 and 34895; all $\times 1$.

Table 3.—Measurements (in mm) of the types of *Ozora genevievensis*, new species.

Specimen no.	Locality	Length	Width	Height	Surface meas.
CM 34893	SL458	44.0	+51.8	28.3	81.0
CM 34894	SL458	40.3	51.0	23.0	68.0
CM 34895	SL458	41.4	51.7	28.5	75.3
CM 34896	SL458	38.9	55.8	11.2	—
Cm 34897	SL458	+34.9	46.5	10.1	—
CM 34898	SL458	37.5	40.7	11.1	—

disc, weakly geniculate trail, producing moderately thick body cavity; greatest width generally at hingeline; lateral slopes steep, subparallel, flaring slightly in some specimens; ears small to medium sized, well-defined by moderate lateral compression; fold and sulcus variably developed or absent; both valves moderately to strongly reticulate, with entire surfaces finely costate and nearly regular rugae on the visceral discs; pedicle valve with row of spines slightly diverging from hingeline, sparsely scattered erect spine bases on flanks and trail, rarely on visceral disc; type species generally with several erect spines bases on flanks near ears; spines apparently lacking on brachial valve but with round pits that may reflect position of spines on opposite valve; cardinal process small to medium sized, sessile, bilobed internally, supported by stout median septum that narrows and extends forward two-thirds to three-quarters length of visceral disc, rising and becoming bladefield anteriorly; lateral ridges diverging little from hingeline, not extending to lateral extremities; adductor field small, raised, with small dendritic posterior adductors and nearly as large, smooth posterior adductors; brachial ridges given off at very low angle to horizontal, extending laterally from anterior edges of posterior adductors; endospines arranged in radial rows on trail.

Comparisons.—The dictyoclostid genus *Antiquatonia* Miloradovich, 1945, and the marginiferid *Inflatia* Muir-Wood and Cooper, 1960, are similar to this new genus, both externally and internally. *Antiquatonia* first appears in the very late Mississippian in North America. It is similar in general shape and ornamentation to *Keokukia* and also has a row of spines along the hingeline. It differs in having a spine-bearing ridge that wraps around the ears onto the flanks, has much larger ears, and the brachial valve has rare spines. Internally, *Antiquatonia* often has the lateral extremities of the brachial valve set off by low folds that reflect the presence of spine ridges on the opposite valve. These few morphologic differences, but especially the lack of the spine ridge around the ears, plus the substantially different stratigraphic distributions of the two genera, are the main basis for proposing this new genus.

Inflatia first appears in late Mississippian beds of Ste. Genevieve age. It is externally similar to *Keokukia* but differs in having larger ears and weaker rugation on the visceral disc. Internally, the lateral ridges of *Inflatia* curve around the ears and along the posterolateral margins as a low ridge, and the brachial ridges are given off anterolaterally, not nearly horizontally as in *Keokukia*.

This new genus is not internally closely similar to any other North American middle Mississippian productaceans. Externally, these shells are similar to the buxtoniid genera *Marginatia* Muir-Wood and Cooper, 1960, or to a lesser extent, *Tomiproductus* Sarycheva, 1963. *Marginatia* generally has a strongly geniculate brachial valve, lacks a row of strong erect spines just anterior to the hingeline,

and has rare spines on the brachial valve. Internally, it is a typical buxtoniid with buttressing plates and an antron, and in addition, has lateral ridges that fuse with a strong marginal rim that wraps around the ears. *Tomiproductus* also is a buxtoniid internally, with buttressing plates, but lacks the rim around the ears. Externally, it differs from *Keokukia* in being much smaller, with finer ribbing, and in having a strongly geniculated brachial valve with rare spines.

Species assigned.—In addition to the type species, only *Keokukia rotunda* n. sp. from the middle Keokuk “oolitic” member can be assigned to this new genus.

Derivation of name.—This new genus is named for the late Osagean Keokuk Limestone.

***Keokukia sulcata*, new species**

Fig. 6.1–7, 6.16–6.19

Holotype.—Fig. 6.16–6.19, a medium-sized pedicle valve, CM 34892, from locality SL477, Monroe County, Illinois.

Paratypes.—Fig. 6.1, 6.2, two brachial valve interiors, CM 34886 and 34887; Fig. 6.3–6.7, two crushed pedicle valves, CM 34888 and 34889; unfigured paratypes, two brachial valve interiors, CM 34934 and 34935; all from the same locality as the holotype.

Description.—Small to medium size for family, length and width subequal, greatest width generally attained at hingeline, rarely anteriorly; outline subovate, lateral profile guttate to subtrigonal; ears of moderate size, well-defined, subangular, slightly mucronate; pedicle valve evenly convex or slightly geniculate, brachial valve more strongly geniculate; trail of moderate length; body cavity moderately thick.

Pedicle valve strongly inflated, most convex in umbonal region; venter flattened umbonally, shallow narrow sulcus originating on visceral disc just anterior to umbo; flanks moderately convex, sloping steeply to lateral margins; lateral extremities almost vertical; ears delimited by concave flexures; umbonal region moderately broad, umbonal angle greater than 90 degrees; beak small, slightly overhanging hingeline; ornament consisting of numerous rounded fine costae, about 6–7 per 5 mm on trail, which increase mainly by bifurcation, rare coarser plications on flanks, and moderately strong irregularly spaced rugae on visceral disc; rugae strongest on sides of umbonal region, weakest on venter; intercostal furrows narrower than costae; spines sparsely and irregularly distributed on venter and flanks, row of seven or more pairs of spines along hingeline, diverging slightly and becoming coarser laterally; commonly with crude cluster of 3–6 coarser halteroid spines on flanks just below ears; growth lines very fine and regularly spaced; interior unknown.

Brachial valve weakly to moderately concave on visceral disc with slightly convex flexures defining ears; trail strongly geniculate, moderately long, weakly concave; fold originating near middle of visceral disc; ornament complementary to opposite valve; spine bases apparently lacking; interior with small to medium, sessile, internally bilobed, externally trilobed cardinal process supported by thick stout median septum that narrows anteriorly, becoming bladelike, extending forward two-thirds or three-quarters length of visceral disc; lateral ridges short, parallel to hingeline, extending less than half way to lateral extremities; muscle field very small, posterior adductors transversely ovate, dendritic; anterior adductors nearly as large, trigonal, smooth, raised on laterally elevated ridges; brachial ridges diverging from horizontal at about 10–15 degree angle; endospines on trail radially arranged.

Measurements.—See Table 4.

Distinguishing characters.—This species is characterized by its fold and sulcus, seven or more pairs of spines along the ventral hingeline, and three to six coarse halteroid spines on the flanks just below the ears.

Remarks.—The other species assigned to this new genus is *Keokukia rotunda* n. sp. from the mid-Keokuk “oolitic” member of St. Louis County, Missouri. The latter differs in being much more strongly inflated with smaller ears, and generally completely lacking a fold and sulcus. In addition, *K. rotunda* has a more strongly concave dorsal visceral disc and stronger lateral ridges.

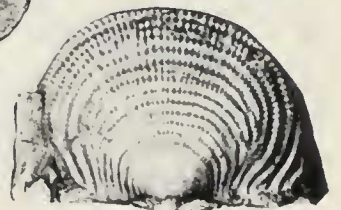
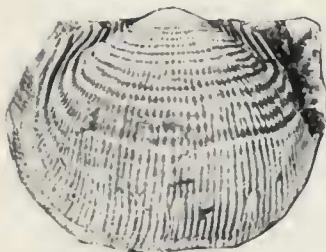
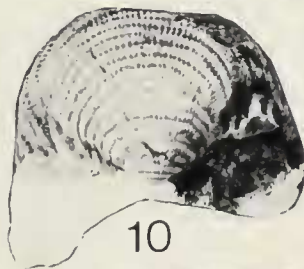
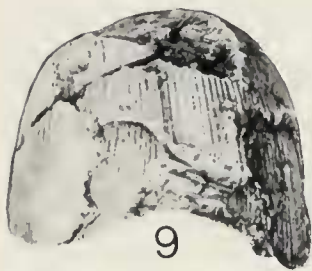
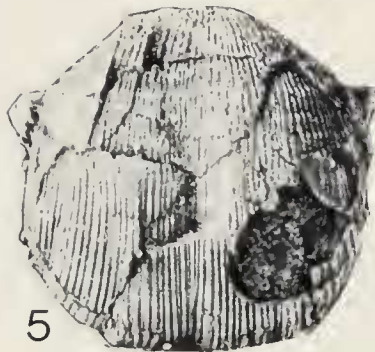
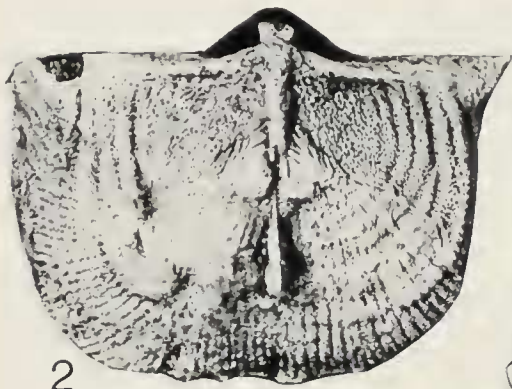
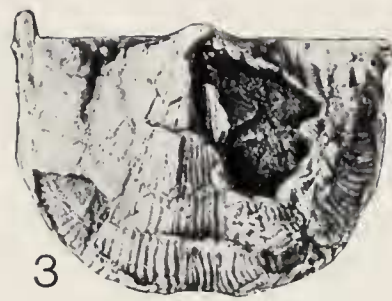
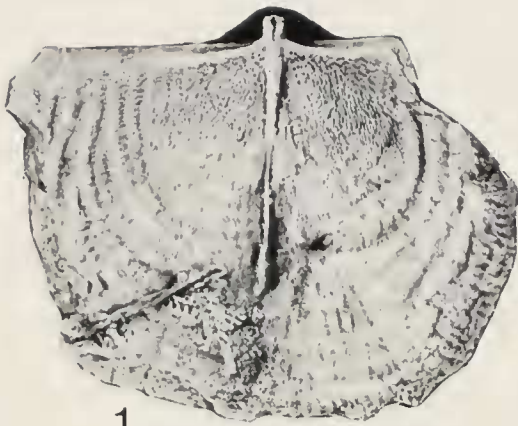


Table 4.—Measurements (in mm) of the types of *Keokukia sulcata*, new species.

Specimen no.	Locality	Length	Width	Height	Surface meas.
CM 34886	SL477	+27.0	+33.9	10.6	—
CM 34887	SL477	26.7	—34.2	11.4	—
CM 34888	SL477	—	39.4	—	56.0
CM 34889	SL477	±37.2	±38.2	—	63.6
CM 34892	SL477	31.1	30.6	18.4	55.7

Productus mesialis Hall, also from the Keokuk Limestone, is similar in having a fold and sulcus, reticulate visceral disc, and a row of spines along the ventral hingeline. It differs from *K. sulcata* in being smaller with a strongly geniculate pedicle valve, a strongly transverse outline, only four pairs of spines along the hingeline, and a nearly flat dorsal visceral disc. The interior of *P. mesialis* is unknown and its relationships cannot be established.

Distribution.—This description is based on two collections totaling 33 specimens, all from the brown shales just above the Keokuk Limestone in the vicinity of St. Louis, Missouri, localities SL477 and SL478.

***Keokukia rotunda*, new species**

Fig. 6.8–6.15

Holotype.—Fig. 6.12–6.15, a natural mold of a brachial valve exterior, CM 34891, from locality SL465, St. Louis County, Missouri.

Paratype.—Fig. 6.8–6.11, a pedicle valve, CM 34890, same locality as the holotype.

Description.—Small to medium size for family, posteriorly strongly reticulate, longer than wide, greatest width attained anterior to hingeline on trail; outline subovate, lateral profile subovate to guttate; ears small, well-defined, subangular, slightly mucronate; pedicle valve evenly convex, most convex in umbonal region; brachial valve moderately concave, producing moderately thick body cavity; trail long on both valves.

Pedicle valve strongly inflated; venter evenly rounded in most specimens, rarely flattened, or even more rarely, with very weak sulcus on trail; flanks sloping steeply to lateral margins, almost parallel in some specimens; lateral extremities weakly concave and slightly flaring; ears delimited by concave flexures; umbonal region inflated, subtending an umbonal angle of about 90 degrees; beak of moderate size, prominently overhanging hingeline; ornament consisting of numerous fine rounded costae or coarse costellae, about 7–9 per 5 mm on trail, which increase mainly by bifurcation; weak undulating plications on trail and flanks, and moderate to strong regularly spaced rugae on visceral disc; intercostal furrows narrower than ribbing; coarse erect spine bases sparsely and irregularly distributed over flanks and venter, more rarely on visceral disc; row of five or more pairs of coarse erect spine bases along hingeline on each side of umbo; growth lines very fine, sinuous, irregularly spaced; interior unknown.

Brachial valve moderately concave on visceral disc with strongly convex flexures defining ears; trail

←
Fig. 6.—6.1–6.7, 6.16–6.19, *Keokukia sulcata*, n. gen., n. sp.; 6.1–6.2, two brachial valve interiors, CM 34886 and 34887, × 1.5; 6.3, 6.4, ventral and lateral views of a crushed pedicle valve, CM 34888, × 1; 6.5–6.7, ventral, lateral and anterior views of a crushed pedicle valve, CM 34889, × 1; 6.16–6.19, ventral, anterior, posterior and lateral views the holotype, CM 34892, × 1; 6.8–6.15, *Keokukia rotunda*, n. gen., n. sp., 6.8–6.11, ventral, anterior, posterior and lateral views of a pedicle valve, CM 34890, × 1; 6.12–6.15, lateral, ventral, anterior and posterior views of the holotype, a natural mold of a brachial valve exterior with a fragment of the pedicle valve attached on the right flank, CM 34891, × 1.

Table 5.—Measurements (in mm) of the types of *Keokukia rotunda*, new species.

Specimen no.	Locality	Length	Width	Height	Surface meas.
CM 34890	SL465	29.9	32.5	23.3	55.2
CM 34891	SL465	26.3	32.5	17.1	41.1

long, moderately geniculate, moderately and evenly concave; fold normally lacking; ornament complementary to opposite valve but with rounded dimples, possibly marking position of spines on opposite valve, spines lacking; interior with medium-sized sessile, internally bilobed cardinal process supported by thick strong median septum that extends forward about two-thirds length of visceral disc; lateral ridges strong, extending laterally three-quarters distance to cardinal extremities; muscle field small, trigonal, inverted chordate, thickened to form adductor platform; brachial ridges nearly horizontal; other internal details not observed.

Measurements.—See Table 5.

Distinguishing characters.—This species is characterized by its strongly inflated profile, rounded venter, small ears, and strongly reticulate visceral disc.

Remarks.—Comparison with *Keokukia sulcata* n. sp. is made above. Other species similar externally to *Keokukia rotunda* n. sp. are *Marginatia burlingtonensis* (Hall, 1858) from the upper Burlington Limestone and *Setigerites altonensis* (Norwood and Pratten, 1855) from the upper Warsaw and Salem formations. *Marginatia burlingtonensis* differs in having larger ears, a distinct ventral sulcus, no spine row on the hingeline, and the pedicle valve is generally slightly geniculate. *Setigerites altonensis* is smaller, weakly reticulate, and has numerous fine spines on both valves, including brushes on the ears of both valves. Internally, both of these species differ greatly and are not closely related to each other or to *Keokukia rotunda* n. sp.

Distribution.—This species is common only in the western portion of St. Louis County, Missouri, in the vicinity of the village of Peerless Park. The collections here consist of 20 specimens at locality SL465 and 13 specimens at locality SL468. It occurs in or just below the beds of the mid-Keokuk "oolite" in this area. It also occurs in the basal part of the Keokuk section exposed at Potter's Branch, Van Buren County, Iowa, SL447. Although a complete Keokuk section is not exposed at this locality, the fossiliferous bed from which these specimens came is only about 20 ft below the geodiferous beds of the lower Warsaw. This horizon may be inferred to be of upper Keokuk age.

Order Athyridida Boucot, Johnson and Staton
Suborder Athyrididina Boucot, Johnson and Staton
Superfamily Athyridacea Davidson
Family Athyrididae Davidson
Subfamily Athyridinae Davidson
Genus *Cleiothyridina* Buckman, 1906

Cleiothyridina valmeyerensis, new species

Fig. 7.1–7.4

Holotype.—Fig. 7.1, a large pedicle valve, CM 34900, collected by the author from locality SL478, St. Louis County, Missouri.

Paratypes.—Fig. 7.2, a large pedicle valve, CM 34901; Fig. 7.3–7.4, a smaller pedicle valve, CM 34902; same locality as the holotype.

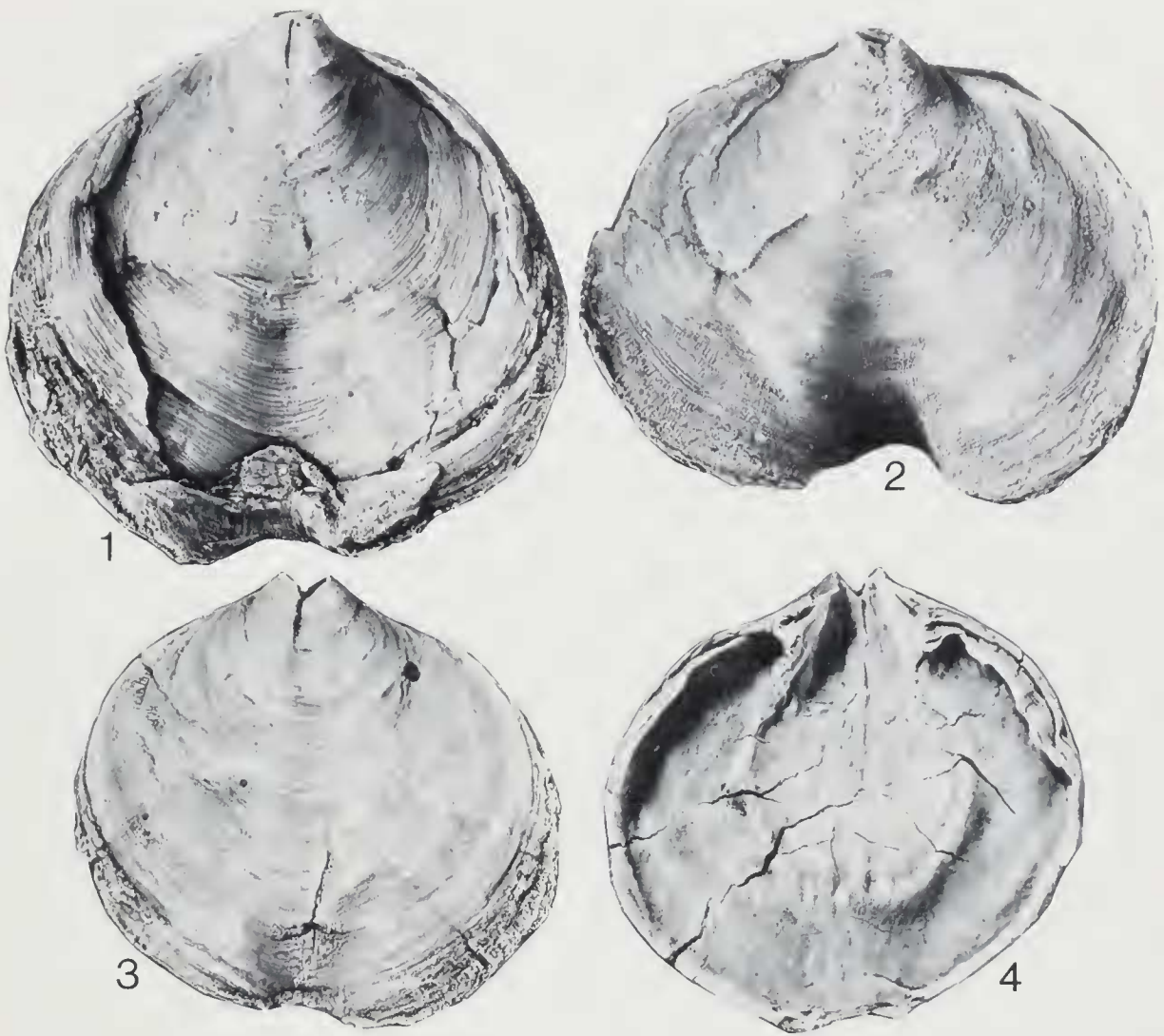


Fig. 7.—7.1–7.4, *Cleiothyridina valmeyerensis*, n. sp.; 7.1, 7.2, two large crushed pedicle valves, CM 34900 (the holotype) and 34901; 7.3, 7.4, exterior and interior views of a small pedicle valve, CM 34902; all $\times 1$.

Description.—Large for genus, unequally biconvex, subcircular to subovate in outline, length and width subequal, generally slightly wider than long; greatest width attained near mid-length; lateral profile lenticular; anterior commissure strongly uniplicate in large adults; fold and sulcus moderately to strongly developed in anterior two-thirds of shell; lateral margins straight or slightly curved; cardinal extremities evenly rounded; ornament consisting of numerous finely and irregularly spaced growth lamellae fringed with fine short flat spines; micro-ornament not observed; shell substance moderately thick.

Pedicle valve most convex in beak region, weakly inflated, much thinner than opposite valve; maximum thickness attained anteriorly at maximum deflection of sulcus; umbonal region broad, slightly inflated; beak broad, short, erect, projecting moderately posterior to hingeline; lateral slopes flattened, very weakly convex; cardinal extremities slightly compressed; delthyrium low, very broad, occluded by umbo of opposite valve; sulcus originating in anterior portion of umbonal region, becoming deeper and broader anteriorly and producing dorsally deflected tongue normal to lateral commissure; entire commissure with distinct dorso-ventral flange; interior with short stout teeth, short diverging dental plates, and very large, spatulate, deeply impressed muscle field that is bordered by raised rim, extending forward two-thirds length of valve.

Brachial valve much more inflated than pedicle valve; fold well-defined, moderately narrow, originating in umbonal region, rising anteriorly; maximum thickness attained anteriorly at maximum height of fold; brachial valve interior unknown.

Table 6.—Measurements (in mm) of the types of *Cleiothyridina valmeyerensis*, new species.

Specimen no.	Locality	Length	Width
CM 34900	SL478	61.5	61.0
CM 34901	SL478	52.0	63.1
CM 34902	SL478	50.2	52.6

Measurements.—See Table 6.

Distinguishing characters.—This species can be recognized by its large size and well-rounded subcircular to subovate outline.

Remarks.—There are many references in the literature to occurrences of the common Burlington Limestone species, *Cleiothyridina obmaxima* (McChesney, 1861), in the Keokuk and Warsaw formations. In fact, the latter seems to range only up to the middle part of the Keokuk Limestone. This new species appears in the upper Keokuk in the Keokuk-Warsaw region but is best developed and attains its largest size in the basal Warsaw shales of St. Louis County, Missouri, and Monroe County, Illinois. *Cleiothyridina obmaxima* differs in being strongly transverse, with much more strongly inflated and evenly convex pedicle valves. *Cleiothyridina incrassata* (Hall, 1858) from the Burlington Limestone is less similar to this new species. It has a subpentagonal to subquadrate outline with an extended, more inflated umbo. In addition, the sulcus in this species originates more anteriorly and becomes broader and shallower than in *C. valmeyerensis*.

Distribution.—This species is common in the basal Warsaw shales of the St. Louis region, localities SL477 and SL478, where large fragments of pedicle valves weather out in considerable numbers. Complete and uncrushed specimens are very rare. The description given above is based mainly on 16 such specimens. It also occurs in the upper Keokuk of southeast Iowa (SL436) and nearby west-central Illinois (SL438).

Order Spiriferida Waagen
 Suborder Spiriferidina Waagen
 Superfamily Paeckelmanellacea Ivanova
 Family Paeckelmanellidae Ivanova
 Subfamily Strophopleurinae Carter
 Genus *Acuminothyris* Roberts, 1963

Acuminothyris keokuk, new species
 Fig. 8.1–8.9

Holotype.—Fig. 8.1, 8.2, a large pedicle valve, CM 34903, collected by the author from the upper Keokuk Limestone, locality SL460, Ste. Genevieve County, Missouri.

Paratypes.—Fig. 8.3–8.7, two pedicle valves, CM 34904 and 34905; Fig. 8.8, 8.9, two incomplete brachial valves, CM 34906 and 34907; all from the same collection as the holotype.

Description.—Medium size for subfamily, moderately biconvex, much wider than long in all observable growth stages; outline transversely fusiform; lateral extremities subangular and alate in all growth stages; greatest width attained at hingeline; narrow, rounded fold and sulcus well-developed, originating at beaks, well-delineated by prominent sulcus-bounding ribs on pedicle valve and deep fold-bounding furrows on brachial valve; anterior commissure uniplicate; ornament consisting of 10–12 simple rounded costae with equally wide rounded intercostal furrows on each flank, and fine,



Fig. 8.—8.1–8.9, *Acuminothyris keokuk*, n. sp.; 8.1, 8.2, ventral and anterior views of the holotype, a large pedicle valve, CM 34903; 8.3–8.5, ventral, anterior and posterior views of a medium-sized pedicle valve, CM 34904; 8.6, 8.7, ventral and posterior views of a small pedicle valve, CM 34905; 8.8, 8.9, dorsal views of two incomplete brachial valve exteriors, CM 34906 and 34907; all $\times 1$.

regularly spaced growth lamellae, about 7–8 per 3 mm; fold and sulcus non-costate; micro-ornament not preserved; shell substance thick, impunctate.

Pedicle valve moderately inflated, evenly convex in lateral profile, with small incurved beak; flanks moderately convex, sloping evenly to lateral extremities; interarea apsacline, low, slightly concave, acutely triangular, with numerous coarse denticle grooves; hingeline denticulate; delthyrium narrow, higher than wide; median septum lacking; dental adminicula not observed in transverse section, if present, buried in umbonal callus.

Brachial valve about as inflated as opposite valve, most convex in umbonal region; flanks concave in only two specimens available for study; fold low but well-differentiated throughout; dorsal interarea not observed; ornament similar to that of opposite valve; interior not observed.

Measurements.—See Table 7.

Distinguishing characters.—This species is characterized by its moderate size, strongly transverse fusiform outline, non-costate fold and sulcus, 10–12 simple rounded costae on each flank, and regularly lamellose ornament.

Remarks.—This is the first report of the genus *Acuminothyris* Roberts, 1963, in North America. However, no interiors of either valve were recovered and the generic assignment is probable, but not certain. Roberts (1963) described this genus as having short dental adminicula supported by a thickening. Preservation of the shell matter of these Missouri shells is very poor due to partial replacement by chert. As a result of this partial replacement, orientation of the fibrous umbonal secondary shell laminae, which would ordinarily indicate the presence or absence of buried dental adminicula in transverse section, is absent. Therefore, it is not possible to determine whether or not dental adminicula are present. In all other respects this Missouri shell fits the generic diagnosis. Because there are no previously described North American spiriferids with this combination of characters, I am assigning this new species to Roberts' genus.

Table 7.—*Measurements (in mm) of the types of Acuminothyris keokuk, new species.*

Specimen no.	Locality	Length	Width	Thickness	Ribs/flank
CM 34903	SL460	16.8	+31.9	6.8	9
CM 34904	SL460	12.5	+29.5	7.3	12
CM 34905	SL460	11.2	30.2	5.6	10
CM 34906	SL460	11.0	—	4.0	+7
CM 34907	SL460	+8.7	+18.4	2.9	10

Externally *Acuminothyris* is similar to some species of the delthyridid genus *Tylothyris* North. However, *Tylothyris* bears a distinct ventral median septum and is readily distinguished on that basis alone.

Distribution.—A single collection consisting of seven pedicle valves and two brachial valves from locality SL460 provided the basis for the description given above.

Superfamily Spiriferacea King

Family Spiriferidae King

Subfamily Prospirinae Carter

Genus *Anthracospirifer* Lane, 1963

Anthracospirifer brecklei, new species

Fig. 9.1–9.25

Holotype.—Fig. 9.13–9.14, a large brachial valve, CM 34912, collected by the author from the lower Warsaw Formation, locality SL442, Lee County, Iowa.

Paratypes.—Fig. 9.1–9.12, four pedicle valves, CM 34908–34911, same collection as the holotype; Fig. 9.15–9.17, small pedicle valve, CM 34913, from the base of the lower Warsaw Formation, locality SL441, Lee County, Iowa; Fig. 9.18–9.19, two medium brachial valves, CM 34914, 34915, from the upper Keokuk Limestone, locality SL447, Van Buren County, Iowa; Fig. 9.20–9.21, a brachial valve and a pedicle valve, CM 34916 and 34917, respectively, from the middle Keokuk Limestone, locality SL468, St. Louis County, Missouri; Fig. 9.22–9.23, a pedicle valve, CM 34918, from the upper Keokuk Limestone, locality SL431, Hancock County, Illinois; Fig. 9.24–9.25, a pedicle valve and the posterior portion of an incomplete shell, CM 34919 and 34920, respectively, from the mid-Keokuk “oolitic” bed, St. Louis County, Missouri; all specimens collected by the author or field associates.

Description.—Small to medium size for genus, subequally biconvex, pedicle valve more inflated than brachial valve; outline transversely subquadrate to subovate in juveniles, commonly becoming more elongated in large adults; greatest width attained near or posterior to mid-length, rarely at hingeline; lateral extremities subangular or slightly rounded; fold and sulcus well-developed, narrow; anterior commissure uniplicate; ornament consisting of 7–12, generally 8–11, strong subangular costae on flanks, and three, rarely five, costae in sulcus, median costa stronger than lateral sulcal costae; sulcus and fold-bounding costae always bifurcate once in umbonal region well-anterior to beak; rare bifurcations on flanks; lateral sulcal costae generally bifurcate from sulcus-bounding costae anterior to lateral umbonal bifurcations of sulcus-bounding costae; strong growth varices irregularly spaced; micro-ornament consisting of very fine and regularly spaced growth lines and strong capillae; shell substance impunctate and of moderate thickness.

Pedicle valve moderately inflated, most convex in umbonal region; maximum thickness attained about perpendicular to hingeline in lateral profile; flanks weakly convex, sloping evenly to lateral margins; cardinal extremities slightly compressed, rarely delineated by weakly concave flexures; umbonal region broad, variably inflated, infrequently extended posteriorly in large adults; beak of moderate size, strongly incurved; beak ridges subangular, well-defined; interarea acutely triangular, low, concave, apsacline, vertically grooved; delthyrium variable in width, generally narrower than high; deltidial closures not observed; hingeline denticulate; sulcus originating in beak region, forming sulcal angle of about 20–28 degrees, shallow and rounded throughout but sharply defined; sulcal costae invariably simple; interior with very short subparallel dental adminicula; other internal details not observed.

Brachial valve moderately inflated but not as thick as opposite valve; most convex in umbonal region with greatest thickness near mid-length, or if fold high, anteriorly; flanks evenly convex except for concave flexures near lateral extremities; umbonal region variable in breadth and posterior protrusion, narrow and protruding posteriorly in holotype but broader and less protruding in paratypes; beak inconspicuous; dorsal interarea very low, concave, anacline; fold originating at beak as low costa sharply delineated by deep fold-bounding furrows, becoming wider and higher anteriorly and of variable height and width; medial intercostal furrow invariably present; interior with small apical

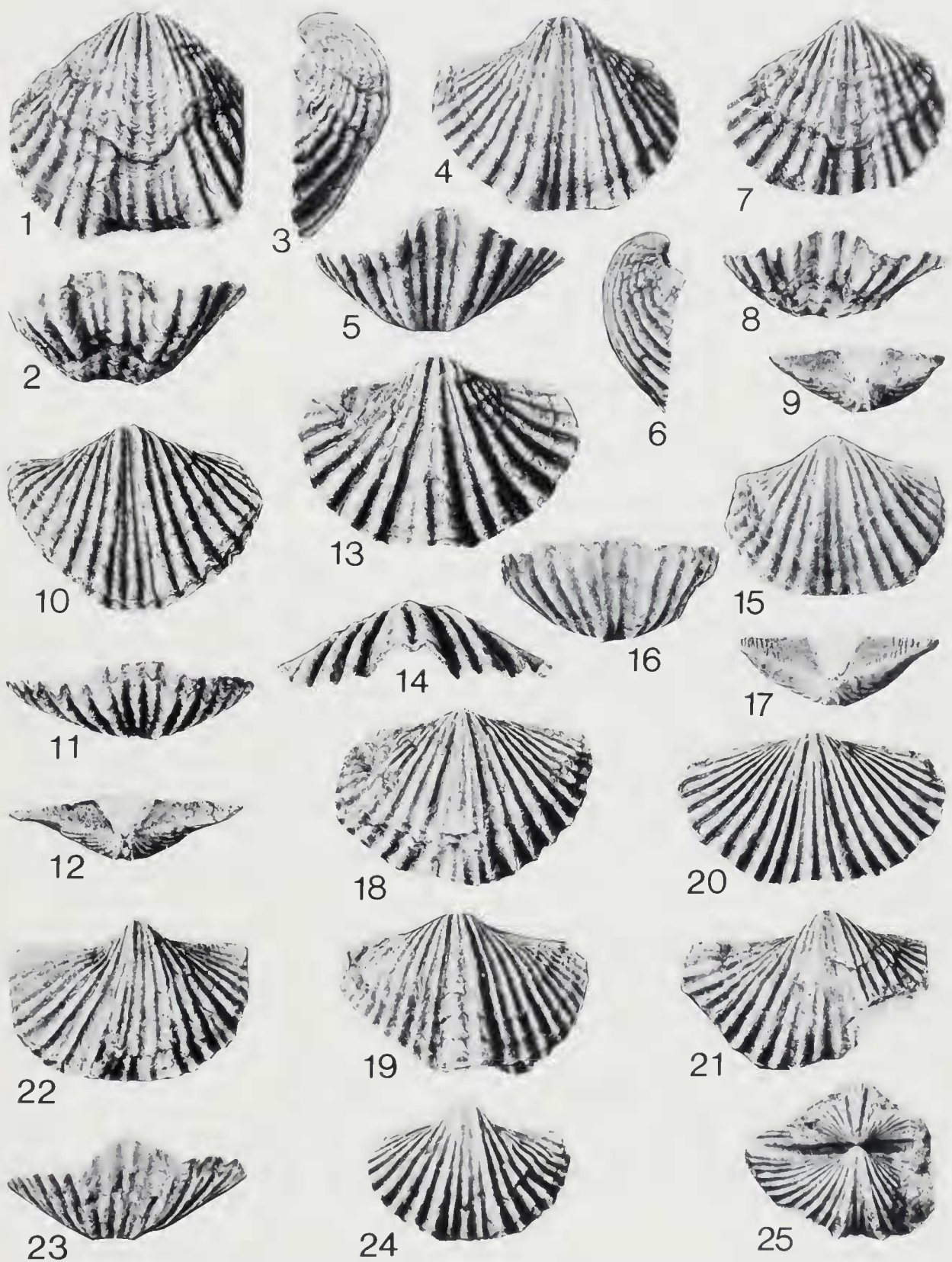


Fig. 9.—9.1–9.25, *Anthracospirifer brenglei*, n. sp.; 9.1–9.6, ventral, anterior and lateral views of two pedicle valves, CM 34908 and 34909; 9.7–9.12, ventral, anterior and posterior views of two pedicle valves, CM 34910 and 34911; 9.13, 9.14, dorsal and anterior views of the holotype, a large brachial valve, CM 34912; 9.15–9.17, ventral, anterior and posterior views of a medium-sized pedicle valve, CM 34913; 9.18, 9.19, two medium-sized brachial valves, CM 34914 and 34915; 9.20, a small brachial valve, CM 34916; 9.21, a medium-sized pedicle valve, CM 34917; 9.22, 9.23, ventral and anterior views of a medium-sized pedicle valve, CM 34918; 9.24, a small pedicle valve, CM 34919; 9.25, posterior view of a small specimen, CM 34920; all $\times 1.5$ except 9.20, 9.21, 9.24 and 9.25, $\times 2$.

Table 8.—Measurements (in mm) of the types of *Anthracospirifer brencklei*, new species.

Specimen no.	Locality	Length	Width	Thickness	Ribs/flank
CM 34908	SL442	20.0	+22.0	9.8	11
CM 34909	SL442	18.7	+23.3	8.0	10
CM 34910	SL442	16.1	20.5	6.1	9
CM 34911	SL442	17.3	22.9	7.0	9
CM 34912	SL442	17.4	26.0	6.3	9
CM 34913	SL441	15.0	20.0	8.1	9
CM 34914	SL447	16.2	24.1	5.6	11
CM 34915	SL447	14.7	23.0	6.9	10
CM 34916	SL468	10.5	18.5	3.1	9
CM 34917	SL468	11.1	—	6.3	10
CM 34918	SL431	15.4	+22.2	6.5	11
CM 34919	SL466	9.8	14.3	3.7	9

callosity supporting cardinal process and very low weak short myophragm; other internal details not observed.

Measurements.—See Table 8.

Distinguishing characters.—This species is characterized by its modest size, 8–11 strong, angular costae with rare bifurcations on the flanks, and three, rarely five, costae in the sulcus.

Remarks.—*Anthracospirifer brencklei* n. sp. appears to be the earliest certain representative of the genus *Anthracospirifer* Lane, 1963, in North America. It first appears in and just below the mid-Keokuk “oolitic” member of the Keokuk Limestone in the St. Louis region and ranges upward throughout much of the lower Warsaw Formation in the Keokuk-Warsaw type region. Another possible *Anthracospirifer* in the Keokuk Limestone is *Spirifer keokuk* Hall, 1858. This species ranges slightly lower in the Keokuk but its generic identity is in doubt. Sutherland and Harlow (1973:77) have succinctly pointed out the morphologic features that characterize the genus *Anthracospirifer*, especially noting that the ribs that bound the fold and sulcus invariably bifurcate once each laterally. In *Spirifer keokuk* these bifurcations are variably developed and are not consistently present at every position. Another troublesome characteristic in *Spirifer keokuk* is the nature of the ribs, which are well-rounded and of moderate amplitude, not strong and subangular ribs as are characteristic of the type species of the genus, *Anthracospirifer birdspringensis* Lane, 1963. Therefore, there is some question as to whether or not *keokuk* should be placed in this genus.

It is probable that some author's references to the occurrence of *Spirifer keokuk* Hall, 1858, and *Spirifer bifurcatus* Hall, 1856, in the lower Warsaw or Keokuk formations included specimens of *Anthracospirifer brencklei* n. sp. To my knowledge *Spirifer keokuk* does not occur above the Keokuk and *Spirifer bifurcatus* does not occur below the upper Warsaw.

Anthracospirifer brencklei n. sp. is most similar to the Chesterian species *Anthracospirifer leidyi* (Norwood and Pratten, 1855). It differs only in having slightly finer ribs, a more variable outline, and the median sulcal costa is not as enlarged relative to the lateral sulcal costae. The lateral extremities in *leidyi* tend to be subangular or even slightly mucronate whereas in *brencklei* they are generally rounded, rarely subangular, but never mucronate.

Although Weller (1914:347) thought that *Spirifer bifurcatus* Hall was similar and related to *Spirifer leidyi*, the two species are probably not related. *Spirifer*

bifurcatus lacks fold and sulcus-bounding costae that bifurcate and is only superficially similar to *S. leidyi* or *A. brencklei* n. sp.

Distribution.—This is a common species in middle Keokuk through lower Warsaw strata of the upper Mississippi Valley region. Although no complete specimens of this species have been found, disarticulated valves and large fragments are common at localities SL431, SL441, SL442, SL447, SL465, SL466, SL468, and at many other localities in this area.

Subfamily Spiriferinae King
Genus *Spirifer* Sowerby, 1816

Spirifer girtyi, new species
Fig. 10.1–10.16

1929 *Spirifer floydensis* Weller?: Girty, 1929, p. 87, pl. 10, fig. 1–5.

Holotype.—Fig. 10.1–10.4, a large pedicle valve, CM 34921, collected by the author from locality SL460, upper Keokuk Limestone, Ste. Genevieve County, Missouri.

Paratypes.—Fig. 10.5–10.16, four pedicle valves and one brachial valve, CM 34922–34926, respectively, from the same collection as the holotype.

Description.—Medium size for genus, subequally biconvex, strongly transverse with alate to mucronate lateral extremities in adults, rounded in juveniles; greatest width attained at hingeline; outline transversely subtrapezoidal; sulcus moderately developed, shallow, rounded, with well-rounded shoulders, poorly differentiated from flanks, incorporating additional costae anteriorly; fold low to moderately high, rounded, better defined than sulcus; ornament consisting of numerous low, rounded, simple or bifurcating costae and irregularly spaced growth varices; micro-ornament consisting of very weak fine capillae, growth lines not observed; shell substance very thick in umbonal region of pedicle valve, impunctate.

Pedicle valve moderately inflated, almost evenly convex in lateral profile, except for maximum convexity in umbonal region; greatest thickness attained near or posterior to mid-length; lateral slopes convex near venter, sloping steeply toward lateral margins, often becoming concave posterolaterally, defining large compressed, alate or slightly mucronate, cardinal extremities; interarea low, acutely triangular, slightly concave, vertically grooved, strongly apsacline; delthyrium about as wide as high; hingeline denticulate; beak ridges sharply defined, angular; sulcus poorly delineated, originating near beak as shallow groove, becoming deeper and rounded anteriorly but remaining shallow or only moderately deep throughout; sulcus-bounding ribs and additional lateral ribs incorporated into sulcus anteriorly; flanks with about 11–14, low, rounded, generally simple costae, up to three of which may bifurcate; sulcus with undivided median rib that originates near beak and up to four or five pairs of simple lateral ribs at anterior commissure, only two of which bifurcate from primary sulcus-bounding costae, others being incorporated from lateral slopes; costae on lateral extremities becoming very faint and difficult to count with estimated total number of costae per valve about 33–37; interior with deeply incised muscle field and short dental adminicula, obscured by thick callus deposits.

Brachial valve less inflated than opposite valve with weakly convex flanks that may become weakly concave posterolaterally, delimiting the cardinal extremities; most convex in umbonal region, sloping gently to lateral and anterior margins; beak inconspicuous; dorsal interarea not observed; fold originating at beak as low rib defined by two deep intercostal furrows, becoming higher and rounded anteriorly, not spreading appreciable as does sulcus; ornamentation complementary to opposite valve; interior unknown.

Measurements.—See Table 9.

Distinguishing characters.—This species can be differentiated by its extended hingeline with alate to slightly mucronate lateral extremities, rounded fold and sulcus, 11–14 low rounded mostly simple costae per flank, and 9 or 11 simple costae in the sulcus at the anterior commissure. The sulcus spreads anteriorly, generally incorporating two costae from the flanks on each side of the sulcus. Internally, the ventral muscle field is deeply incised, and the short dental adminicula and umbonal chamber are obscured by thick callus deposits.

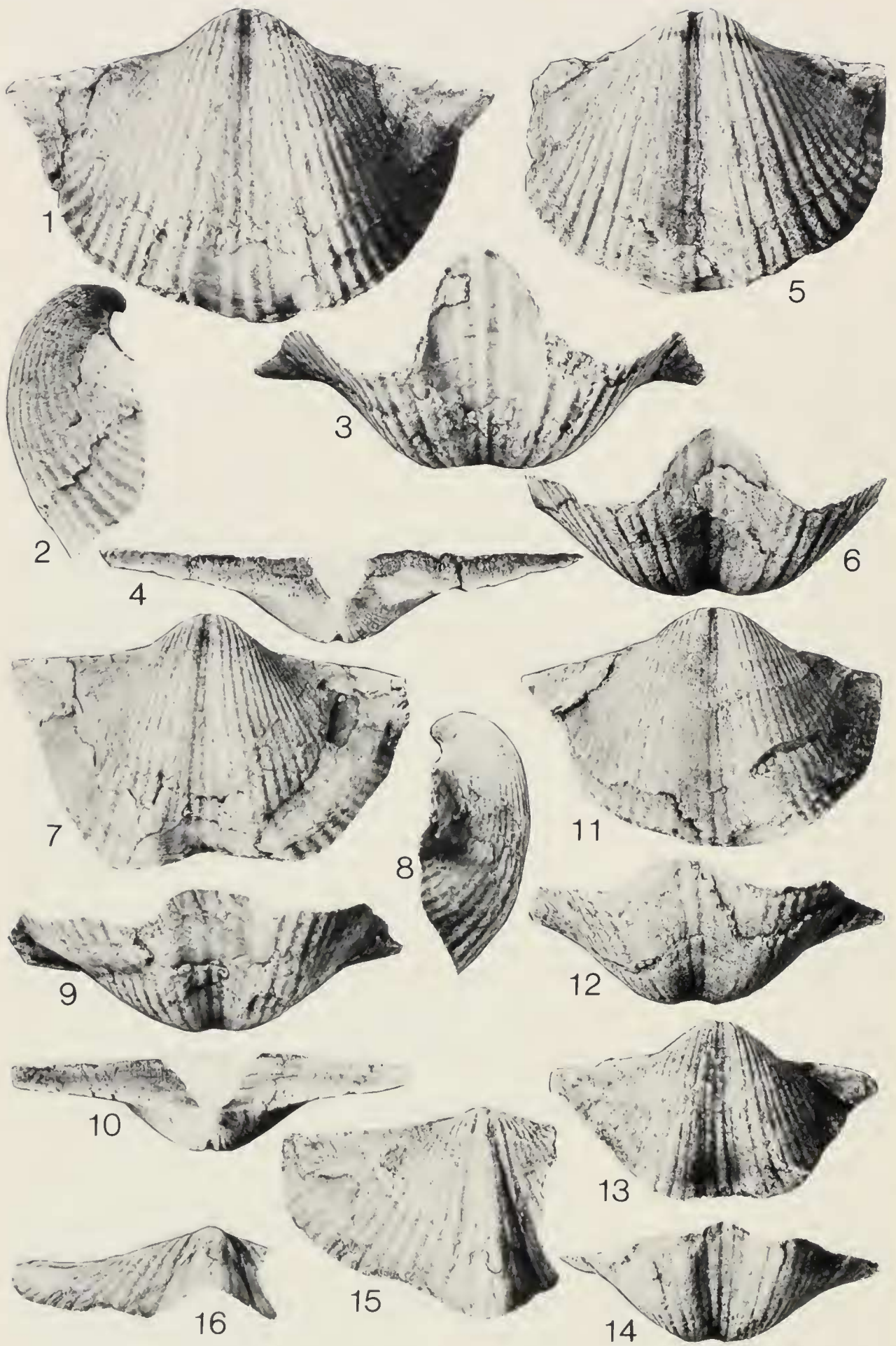


Table 9.—Measurements (in mm) of the types of *Spirifer girtyi*, new species.

Specimen no.	Locality	Length	Width	Thickness	Total ribs
CM 34921	SL460	48.4	70.2	17.4	36
CM 34922	SL460	43.6	+54.5	18.4	33
CM 34923	SL460	38.7	+58.9	17.0	35
CM 34924	SL460	35.8	+54.4	13.5	34
CM 34925	SL460	26.0	48.8	11.7	33
CM 34926	SL460	30.4	±60.0	10.5	—

Remarks.—The specimens from the Boone Formation near Batesville, Arkansas, described and illustrated by Girty (1929) as *Spirifer floydensis* Weller? are definitely assignable to this new species, and the species is named in honor of G.H. Girty for first discovering and illustrating the taxon.

Although Girty (1929) tentatively assigned this species to *Spirifer floydensis* Weller, 1914, he discussed in much more detail its similarity to *Spirifer arkansanus* Girty, which is from a much younger horizon. *Spirifer floydensis* is smaller with a much narrower hingeline and has finer, more numerous costae than does *S. girtyi* n. sp. *Spirifer arkansanus* Girty is similar in size and general aspect to this new species but differs in lacking an extended hingeline and in having more numerous costae, many of which bifurcate on the flanks, and a more complex sulcal bifurcation pattern.

Distribution.—The description given above is based on a single collection of 70 specimens from the upper Keokuk Limestone at locality SL460, Ste. Genevieve County, Missouri. The only other known occurrence of this species is that discussed above from the middle Boone Formation near Batesville, Arkansas.

Order Spiriferinida Ivanova
 Suborder Spiriferinidina Ivanova
 Superfamily Spiriferinacea Davidson
 Family Punctospiriferidae Waterhouse
 Genus *Punctospirifer* North, 1920

Punctospirifer monroensis, new species
 Fig. 11.1–11.4

Holotype.—Fig. 11.4, a pedicle valve, CM 34930, collected by the author from the basal Warsaw shales at locality SL477, Monroe County, Illinois.

Paratypes.—Fig. 11.1, a crushed specimen in posterior view, CM 34927; Fig. 11.2, 11.3, two crushed specimens in dorsal view, CM 34928 and CM 34929; all collected by the author from locality SL478, St. Louis County, Missouri.

Description.—Medium size for genus, subequally biconvex, pedicle valve slightly thicker than brachial valve; outline transversely semicircular, much wider than long with alate cardinal extremities;

←
 Fig. 10.—10.1–10.16, *Spirifer girtyi*, n. sp.; 10.1–10.4, ventral, lateral, anterior and posterior views of the holotype, a large pedicle valve, CM 34921; 10.5–10.6, ventral and lateral views of a large pedicle valve, CM 34922; 10.7–10.10, ventral, lateral, anterior and posterior views of a large pedicle valve, CM 34923; 10.11–10.14, ventral and anterior views of two medium to small pedicle valves, CM 34924 and 34925; 10.15, 10.16, dorsal and anterior views of an incomplete brachial valve, CM 34926; all × 1.

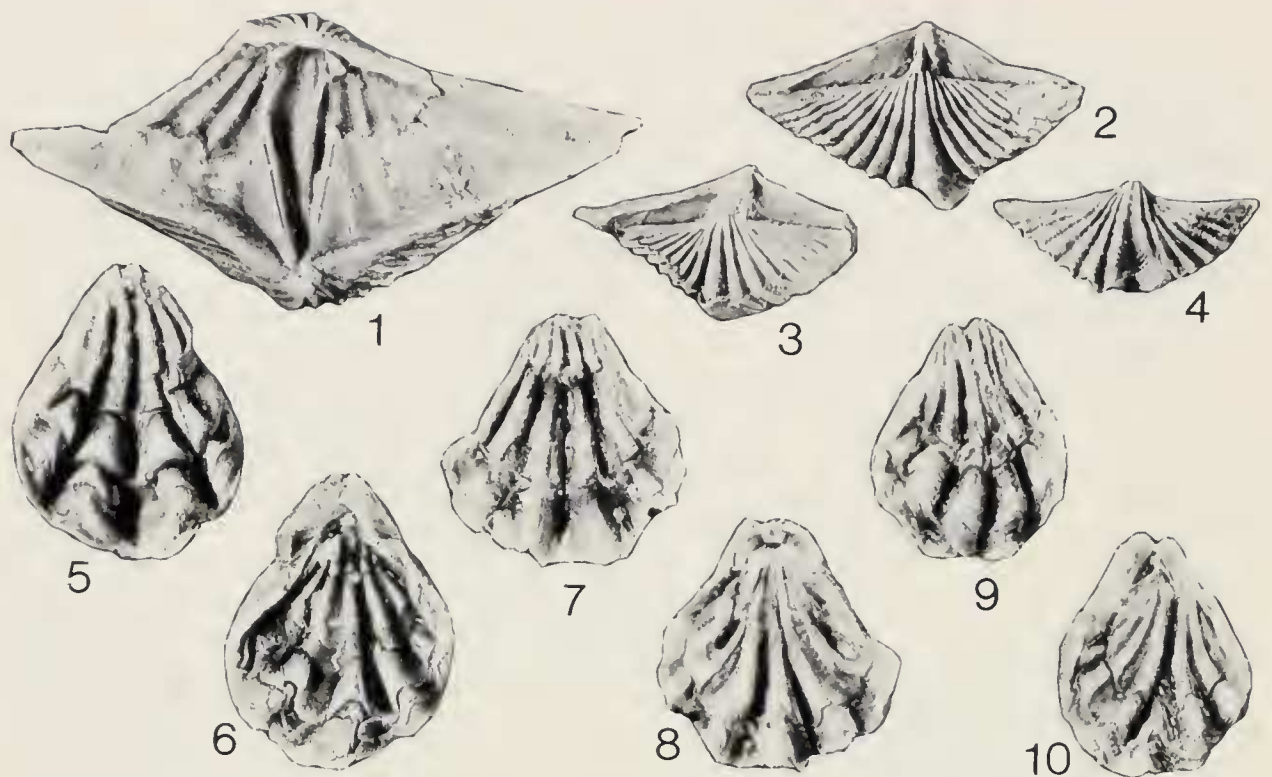


Fig. 11.—*Punctospirifer* and *Plectospira*; 11.1–11.4, *Punctospirifer monroensis*, n. sp.; 11.1, posterior view of a longitudinally crushed specimen, CM 34927, $\times 2$; 11.2, 11.3, dorsal views of two crushed specimens, CM 34928 and 34929, $\times 1$; 11.4, ventral view of a pedicle valve, the holotype, CM 34930, $\times 1$; 11.5–11.10, *Plectospira juvenis*, n. sp.; 11.5, 11.6, ventral and dorsal views of the crushed holotype, CM 34931; 11.7–11.10, ventral and dorsal views of two crushed specimens, CM 34932 and 34933; all $\times 3$.

greatest width attained at hingeline in all observable growth stages; fold and sulcus moderately well-developed, narrow, well-defined, well-rounded, anterior commissure uniplicate; ornament consisting of 7–9 strong, simple, high, subangular plicae on each flank and irregularly spaced growth varices; growth lamellae moderately and regularly lamellose or imbricate, anteriorly fringed with minute spinules; shell substance densely and coarsely punctate.

Pedicle valve moderately convex medially, most convex umbonally, flanks sloping evenly to lateral margins; beak small, almost straight or slightly incurved; beak ridges strong, angular; sulcus originating at beak, well-defined by angular lateral margins, remaining shallow and rounded throughout; interarea moderately high, acutely triangular, angle of inclination not determinable; delthyrium narrow, much higher than wide, occluded at apex by small callus; interior with slender short dental adminicula and long high median septum; other internal details not observed.

Brachial valve moderately inflated, most convex umbonally; beak tiny, inconspicuous; fold originating at beak as low rounded plication, rising anteriorly, becoming well-delimited by deep fold-bounding grooves, remaining well-rounded throughout; dorsal interarea very low, concave, acutely triangular, anacline; interior with small striate cardinal process, weak low median ridge that extends forward to about mid-length, strong inner socket ridges that are directed anterolaterally and are attached to inner fold-bounding ridges by long, very slender tabellae; other internal details not observed.

Measurements.—See Table 10.

Distinguishing characters.—This species can be differentiated by its strongly transverse alate outline, 7–9 strong, angular plications per flank, rounded simple fold and sulcus, and slender tabellae internally.

Remarks.—Few representatives of the genus *Punctospirifer* have been described from rocks of this age in North America. This new species is not very similar to *Punctospirifer salemensis* (Weller, 1914) from the Salem Limestone, which has only about five ribs per flank. *Punctospirifer acutus* Carter, 1968, from the lower

Table 10.—*Measurements (in mm) of the types of Punctospirifer monroensis, new species.*

Specimen no.	Locality	Length	Width	Ribs/flank
CM 34927	SL478	—	±31.7	8
CM 34928	SL478	−18.9	−33.9	10
CM 34929	SL478	−15.9	+29.0	9
CM 34930	SL477	11.7	27.2	8

Burlington Limestone of Missouri, is similar in outline and general aspect but differs in having fewer ribs, more mucronate cardinal extremities, and in addition, is much smaller. *Spiriferina northviewensis* Branson, 1938, from the Northview Shale of southwestern Missouri is also much smaller than this new species and the lateral extremities are not as extended. However, in ribbing and other details it is similar to *P. monroensis* n. sp.

Distribution.—This new species has been found at only two localities, both in the basal Warsaw Shales of the St. Louis region. The largest collection, consisting of 16 crushed specimens, is from locality SL478, St. Louis County, Missouri. The other, smaller collection, consists of only nine specimens, including the holotype, and is from locality SL477, Monroe County, Illinois.

Suborder Reziidina Boucot, Johnson and Staton
 Superfamily Retziacea Waagen
 Family Retziidae Waagen
 Genus *Plectospira* Cooper, 1942
Plectospira juvenis, new species
 Fig. 11.5–11.10

Holotype.—Fig. 11.5, 11.6, a large crushed specimen, CM 34931, collected by the author from the basal Warsaw Shale at locality SL477, Monroe County, Illinois.

Paratypes.—Fig. 11.7–11.10, two crushed specimens, CM 34932 and 34933, respectively, from the same collection as the holotype.

Description.—Medium size for genus, longitudinally guttate in outline, much longer than wide, biconvex, convexity not determinable in types due to compression; greatest width attained anteriorly; ventral beak small, probably suberect to erect; foramen round; dorsal beak small, narrow, inconspicuous; hingeline narrow, curved; fold and sulcus poorly defined, if present; ornament of pedicle valve consisting of six or eight strong rounded plications, separated by nearly equally broad rounded furrows; brachial valve with five or seven plicae; strong growth varices irregularly spaced; micro-ornament not observed; shell substance finely punctate.

Pedicle valve with medial interplical furrow slightly wider than lateral furrows in holotype, possibly representing ventral sulcus; delthyrium closed by conjunct deltidial plates; interior unknown.

Brachial valve with ornament complementary to opposite valve; medial plica spreading anteriorly, possibly representing fold; interior unknown.

Table 11.—*Measurements (in mm) of the types of Plectospira juvenis, new species.*

Specimen no.	Locality	Length	Width	Total ribs
CM 34931	SL478	−10.0	−7.8	6
CM 34932	SL478	−8.4	−8.1	8
CM 34933	SL478	−8.1	−6.5	8

Measurements.—See Table 11.

Distinguishing characters.—This species is characterized by its modest size, elongated guttate outline, six or eight plicae on the pedicle valve and five or seven plicae on the brachial valve.

Remarks.—These three specimens are all greatly compressed by sediment compaction and accurate measurements and description of proportions is impossible. However, it is possible to suggest that in an inflated condition all of these three specimens would be more elongated than they appear here. Although these poor specimens present difficulties in description they reflect the latest representation of this genus in North America. The morphological characters that are preserved are sufficient to be certain that the specimens represent an undescribed species.

Only four other species of this genus have been described in North America. These are *Plectospira sexplicata* (White and Whitfield, 1862) from the Kinderhookian and lower Osagean of the mid-continent, *Plectospira problematica* (Girty, 1926) from the Chappel Limestone of central Texas, *Plectospira magniplicata* (Branson, 1938) from the Northview Shale of southwestern Missouri, and *Plectospira magna* (Hyde, 1953) from the Logan Formation of Ohio. *P. juvenis* n. sp. differs from all of these species in having an elongated guttate outline.

Distribution.—The three specimens illustrated here from locality SL477 constitute the only collection of this species.

ACKNOWLEDGMENTS

Field work was supported by grants from the Amoco Production Company and the M. Graham Netting Research Fund. Paul Brenckle and Albert Kollar collaborated in collecting the fossils, for which I am grateful. I thank Richard E. Grant and T. W. Henry for their thoughtful reviews and helpful suggestions.

LITERATURE CITED

- BRANSON, E. B. 1938. Stratigraphy and paleontology of the Lower Mississippian of Missouri, Part 2. University of Missouri Studies, 13(4):1-242.
- BRENCKLE, P. D., AND H. R. LANE. 1981. The type Meramec. Pp. 13-30, in Mississippian stratotypes (Charles Collinson, et al., eds.), Illinois State Geological Survey Field Guidebook:1-56.
- CARTER, J. L. 1968. New genera and species of early Mississippian brachiopods from the Burlington Limestone. Journal of Paleontology, 42:1140-1152.
- COLLINSON, C., J. W. BAXTER, AND R. D. NORBY. 1981. Mississippian stratotypes. Illinois Geological Survey Field Guidebook:1-56.
- GIRTY, G. H. 1911. The fauna of the Moorefield Shale of Arkansas. U.S. Geological Survey, Bulletin 439:1-148.
- . 1926. The macro-fauna of the limestone of Boone age. Pp. 24-43, in Mississippian formations of San Saba County, Texas (P. V. Roundy, G. H. Girty, and M. I. Goldman, eds.). U.S. Geological Survey Professional Paper 146:1-63.
- . 1929. The fauna of the middle Boone near Batesville, Arkansas. U.S. Geological Survey Professional Paper 154:73-103.
- HALL, J. 1856. Description of new species of fossils from the Carboniferous limestones of Indiana and Illinois. Transactions of the Albany Institute, 4:1-36.
- . 1858. Paleontology of Iowa. Iowa Geological Survey, 1(part 2):473-724, 29 pls.
- HYDE, J. E. 1953. Mississippian formations of central and southern Ohio. Ohio Geological Survey, Bulletin 51:1-355.
- LANE, N. G. 1963. A silicified Morrowan brachiopod faunule from the Bird Spring Formation, southern Nevada. Journal of Paleontology, 37:379-392.
- MCCHESENEY, J. H. 1861. Descriptions of new fossils from the Paleozoic rocks of the western states. Chicago Academy of Sciences, Transactions 1:77-96.
- MILORADOVICH, B. V. 1945. [Some data on the morphology of the shells of the Productidae]. Bulletin de l'Académie des Sciences de Union des Républiques Soviétiques Socialiste (Biologique), 4:485-500. (In Russian.)

- MUIR-WOOD, H. M., AND G. A. COOPER. 1960. Morphology, classification and life habits of the Productoidea (Brachiopoda). Geological Society of America, Memoir 81:1-447.
- NORWOOD, J. G., AND H. PRATTEN. 1855. Notice of producti found in the western states and territories with descriptions of twelve new species. Academy of Natural Sciences of Philadelphia, Series 2, 3(part 1):5-22.
- ROBERTS, J. 1963. A Lower Carboniferous fauna from Lewinsbrook, New South Wales. Royal Society of New South Wales, Journal and Proceedings, 97:1-29.
- ROBERTS, J., J. W. HUNT, AND D. M. THOMPSON. 1976. Late Carboniferous marine invertebrate zones of eastern Australia. Alcheringa, 1:197-225.
- SARYCHEVA, T. G. 1949. [Morphology, ecology and evolution of Carboniferous producti of the Moscow Basin: genera *Dictyoclostus*, *Pugilis*, and *Antiquatonia*]. Akademiya Nauk S.S.S.R., Paleontologicheskii Institut, Trudy, 18:1-304.
- SARYCHEVA, T. G., A. N. SOKOLSKAYA, G. A. BESNOVA, AND S. V. MAKSIMOVA. 1963. Brachiopody i paleogeografiya karbona Kuznetskoi kotloviny. Akademiya Nauk S.S.S.R., Paleontologicheskii Institut, Trudy, 95:1-547.
- SUTHERLAND, P. K., AND F. H. HARLOW. 1973. Pennsylvanian brachiopods and biostratigraphy in southern Sangre de Cristo Mountains, New Mexico. New Mexico Bureau of Mines and Mineral Resources, Memoir 27:1-173.
- SUTTON, A. H. 1938. Taxonomy of Mississippian Productidae. Journal of Paleontology, 12(6):537-569.
- THACKER, J. L., AND I. R. SATTERFIELD. 1977. Guidebook to the geology along Interstate 55 in Missouri. Missouri Geological Survey, Report of Investigations 62:1-132.
- VAN TUYL, F. M. 1925. The stratigraphy of the Mississippian formations of Iowa. Iowa Geological Survey, Annual Reports, 1921 and 1922, 30:33-374.
- WELLER, S. 1914. The Mississippian Brachiopoda of the Mississippi Valley Basin. Illinois Geological Survey, Monograph 1:1-508, 83 pls.
- WHITE, C. A., AND R. P. WHITFIELD. 1862. Observations upon the rocks of the Mississippi Valley, which have been referred to the Chemung Group of New York, together with descriptions of new species of fossils from the same horizon at Burlington, Iowa. Boston Society of Natural History, Proceedings, 8:289-306.

